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(54) Abstract Title

Electrical measuring equipment

(57) Electrical measuring equipment (1) for the production of an electrical signal (OUT) corresponding with a physical magnitude comprises at least two sensors (3, 4) for measurement of the magnitude and for production of measurement values and an electrical circuit (5, 6, 7) for production of an electrical signal (I) corresponding with the magnitude when the measurement values do not deviate substantially from each other or for production of an electrical signal (K) denoting a fault when the measurement values do deviate substantially from each other.

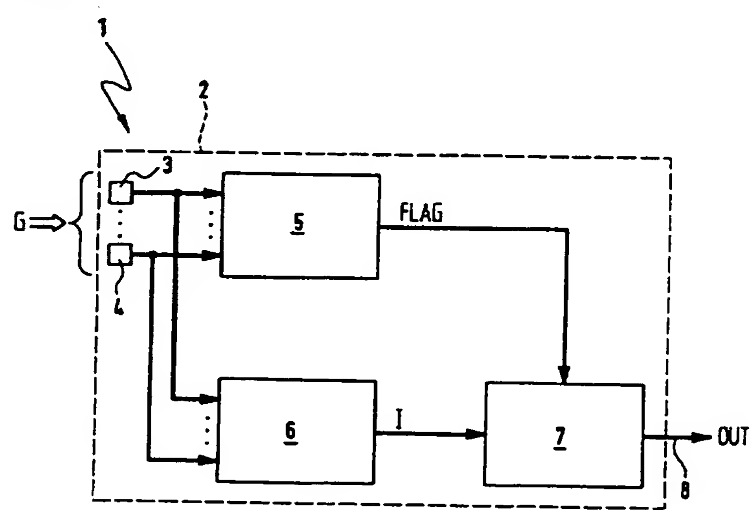

Fig. 1

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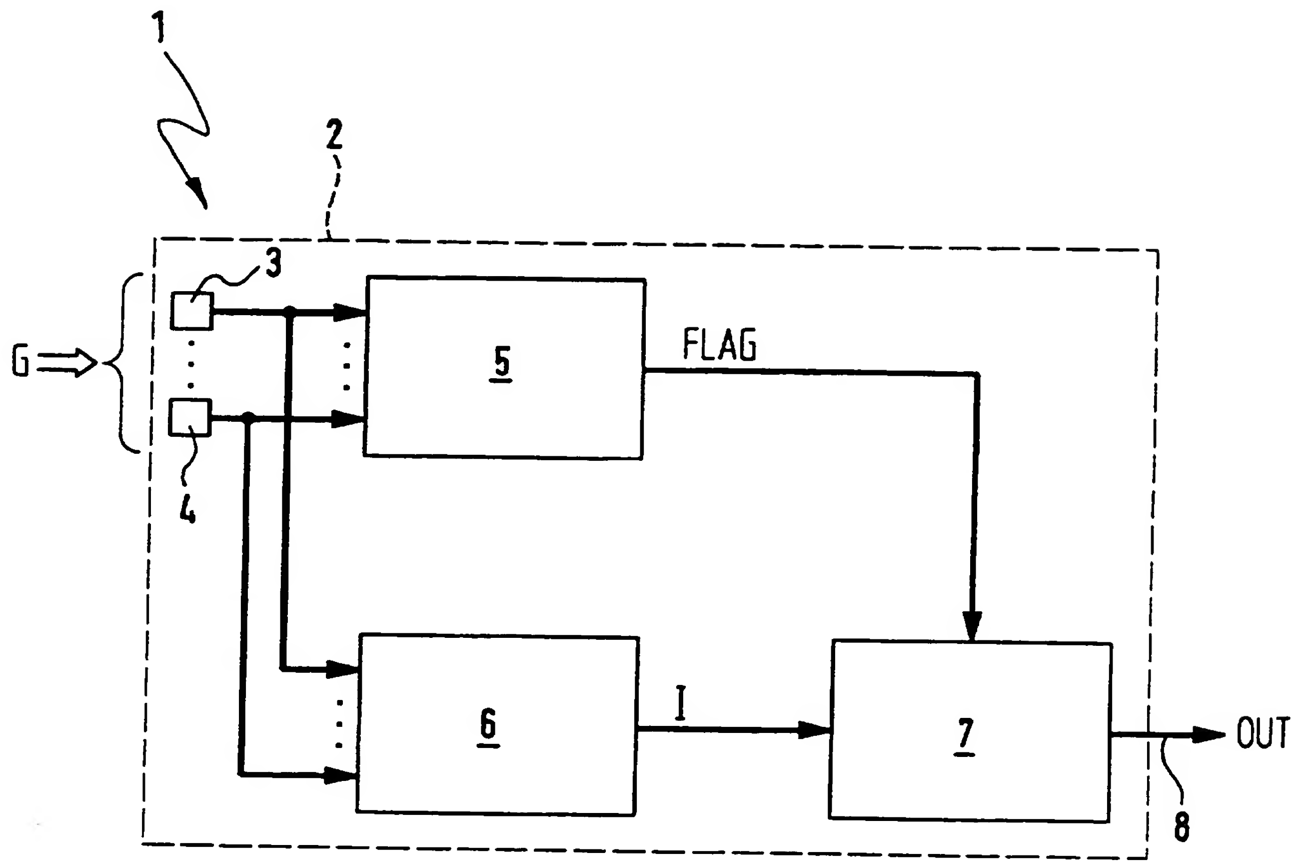


Fig. 1

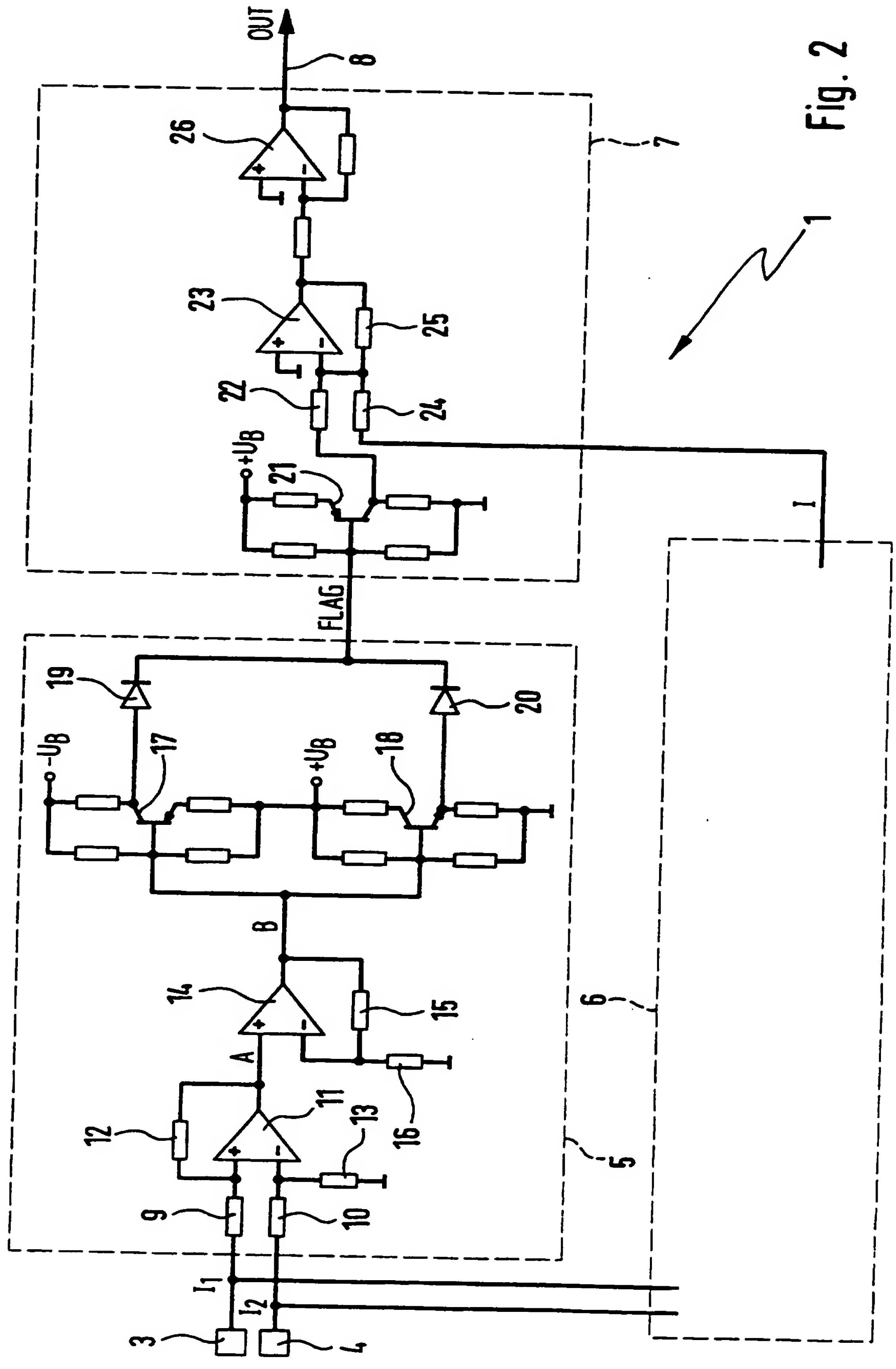
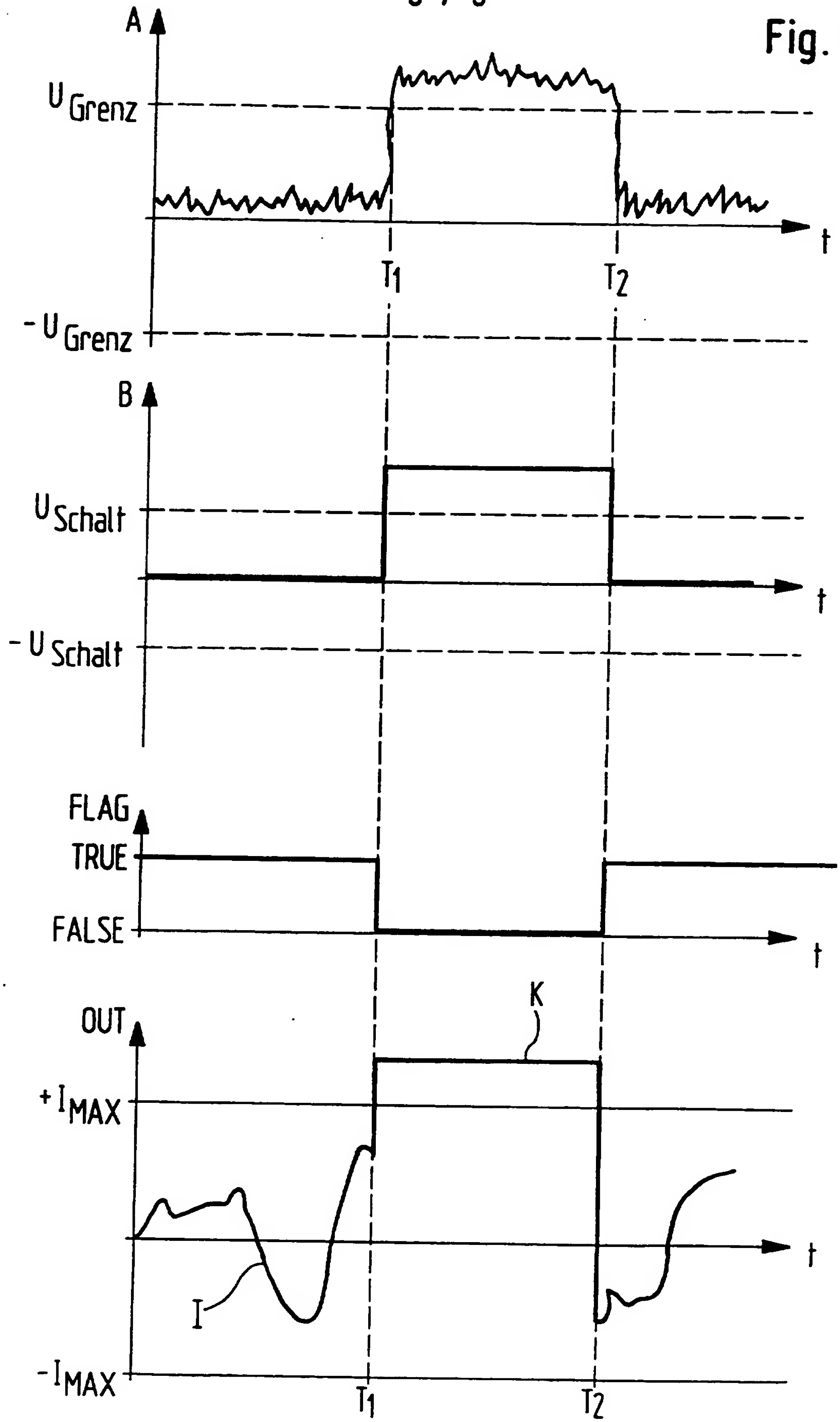

OUT
8
26
7
23
25
22
24
$+U_B$
21
I
1
FLAG
19
20
$-U_B$
17
$+U_B$
18
B
14
15
A
11
12
13
16
5
6
9
10
I_1
I_2
3
4

Fig. 2

Fig. 3


A
U_{Grenz}
t
T_1
T_2
$-U_{Grenz}$
B
U_{Schalt}
t
$-U_{Schalt}$
FLAG
TRUE
FALSE
t
OUT
K
$+I_{MAX}$
t
I
$-I_{MAX}$
T_1
T_2

ELECTRICAL MEASURING EQUIPMENT AND METHOD FOR PRODUCING AN ELECTRICAL SIGNAL

The present invention relates to electrical measuring equipment and a method for the production of an electrical signal corresponding with an actual magnitude, especially for the production of an electrical signal corresponds with a physical magnitude in a motor vehicle.

Particularly in the case of motor vehicles, electrical sensors or measuring equipment are increasingly used for measuring physical magnitudes, for example the rotational speed of the vehicle internal combustion engine or the pressure in a pressure chamber of a fuel pump or the like. In that case, it is necessary that the measurement values produced by the sensors or the measuring equipment correspond with the actual physical magnitudes in every case. In order to guarantee this, one and the same physical magnitude is measured by several sensors in present-day systems. Measurement values measured by the sensors are then passed on by way of output lines to an electrical circuit or, in particular, to a microcomputer which compares the received measurement values with each other. The computer ascertains by reference to preset plausibility criteria whether the measurement values measured by the different sensors reliably correspond with the actual magnitude. Thus, in the case of a deviation of the received measurement values which exceeds a preset maximum value, the microcomputer concludes that a fault is present. After the microcomputer has recognised such a fault, it can pass over into an associated fault routine and, for example, report the fault to the driver of the vehicle.

Due to the ever greater number of sensors and items of measuring equipment in a motor vehicle, the described plausibility check of the received measurement values has become more laborious. This leads to a not insubstantial loading of the microcomputer by the mentioned plausibility checks.

It would thus be desirable to create electrical measuring equipment and associated method which may load such a microcomputer to only the absolutely necessary extent.

According to a first aspect of the present invention there is provided electrical measuring equipment comprising at least two sensors for measurement of the actual magnitude and production of measurement values and an electrical circuit for production of the electrical

signal corresponding with the actual magnitude when the measurement values do not deviate substantially from each other and for production of an electrical signal characterising a fault when the measurement values do deviate substantially from each other.

According to a second aspect of the invention there is provided a method in which at least two measurement values of the actual magnitude are produced and either the electrical signal corresponding with the actual magnitude is produced when the measurement values do not deviate substantially from each other or an electrical signal characterising a fault is produced when the measurement values do deviate substantially from each other.

Thus, an intelligent electrical measuring equipment or method is created in which, by contrast to the state of the art in which a plausibility check is performed by a microcomputer, such a check is integrated into the equipment or method. This means that the equipment or method itself carries out a fault-finding check. If a fault is ascertained during this check, the equipment or the method itself can report this fault to a connected microcomputer. This has the consequence that the microcomputer need no longer perform plausibility checks. The microcomputer can take over the electrical signal, without further checking, as the signal corresponding with the actual magnitude and process it further. If a fault is present, this fault is reported to the microcomputer with the aid of an appropriate electrical signal. The microcomputer need not perform any further plausibility checks or the like, but can pass over directly into, for example, a fault routine. The microcomputer thus need have nothing more to do with the checking of the equipment or method. This checking is performed by the equipment or the method itself.

In a preferred embodiment, the equipment comprises only one output line, on which either the signal corresponding with the actual magnitude or the signal characterising the fault is present. The equipment thus has only one single output line, like sensors known in the state of the art. By contrast to the known sensors in which only the signal corresponding with the measured magnitude is present on the output line, the equipment makes available either the signal corresponding with the actual magnitude or the signal characterising the fault. The output signal of the measuring equipment thus has a substantially higher information content than the output signal of known sensors. This higher information content can be taken into consideration by the connected microcomputer and utilised for further processing.

Moreover, it is possible to replace existing sensors by measuring equipment embodying the invention. Only an appropriate reprogramming of the microcomputer is then required to adapt the microcomputer to such equipment.

In a further preferred embodiment the signal characterising the fault lies outside the range of the signal corresponding with the actual magnitude. This means, for example, that the voltage value of the signal characterising the fault does not lie within the voltage range of the signal corresponding with the actual magnitude. These signals thus do not overlap. In this manner, it is readily possible for the microcomputer to distinguish the two signals. This represents an extremely simple, but secure and reliable mode and manner, by which the signal characterising the fault and the signal corresponding with the actual magnitude can be produced to be distinguishable on one and the same output line.

For preference, the at least two sensors measure the actual magnitude in different manners. It is thereby achieved that, for example, systematic faults, which would have an effect on only a certain type of sensor, are recognised securely and reliably. Moreover, it is ensured thereby that the simultaneous failure of several sensors is highly unlikely.

It is particularly advantageous if the electrical circuit comprises a comparator which produces a comparison signal dependent on the mutual deviation of the measurement values. The comparison signal can be in binary form. In this case, the comparison signal can either indicate that the deviation of the measurement values exceeds a preset maximum value and is in that case significant or that the deviation does not exceed this maximum value and is thus insignificant.

Preferably, the electrical circuit comprises a filter or the like, which produces a filter signal corresponding with the measurement values. This means that the filter can, with the aid of appropriate measures, produce a filter signal from the different measurement values, which filter signal for example corresponds with a mean value of all measurement values. The filter signal thus represents the electrical signal which comes nearest to the actual magnitude.

Moreover, it is particularly advantageous if the electrical circuit comprises an evaluator which in dependence on the binary comparison signal either passes on the filter signal or

produces the electrical signal characterising the fault. The evaluator thus decides in dependence on the comparison signal whether the filter signal coming nearest to the actual magnitude is passed on to the output line or whether the electrical signal characterising the fault is produced and applied to the output line. It is thus possible with the aid of the evaluator to apply either the signal corresponding with the actual magnitude or the signal characterising the fault to the output line.

An embodiment of the equipment and example of the method of the present invention will now be more particularly described with reference to the accompanying drawings, in which:

Fig. 1 is a schematic block diagram of electrical measuring equipment embodying the invention;

Fig. 2 is a schematic circuit diagram of the measuring equipment of Fig. 1; and

Fig. 3 is a set of time diagrams of signals present in the measuring equipment according to the circuit diagram of Fig. 2.

Referring now to the drawings, electrical measuring equipment 1, which is provided in particular for the measurement of physical magnitudes in a motor vehicle, is illustrated in Fig. 1. The equipment 1 is suitable for measuring, for example, the rotational speed of the vehicle internal combustion engine or the pressure in a pressure chamber of a fuel pump of the vehicle.

A plurality of sensors 3 and 4, a comparator 5, a filter 6 and an evaluator 7 are housed in a housing 2 receiving the equipment 1. Although only two sensors 3 and 4 are illustrated, the number of sensors can be greater.

A physical magnitude G is measured with the aid of the sensors 3 and 4. In that case, the same physical magnitude G is measured by all the sensors present.

The sensors 3 and 4 produce respectively associated measurement values which act on the comparator 5 and the filter 6. In the case of more sensors being present, all measurement values produced by these sensors act on the comparator and filter.

The received measurement values are compared with each other by the comparator 5. If, for example, at least two of the received measurement values have a deviation from each other greater than a preset maximum value, then the comparator 5 produces a comparison signal FLAG, which has the binary value FALSE. If, thereagainst, the deviations between the received measurement values are all smaller than the preset maximum value, the comparator 5 produces the binary value TRUE as comparison signal FLAG.

It is self-evident that the comparator 5 can produce the binary comparison signal FLAG in other mode and manner. All feasible forms of checking the received measurement values with respect to their correct representation of the actual magnitude G are admissible. Similarly, all feasible plausibility checks or the like are admissible, by which the deviations of the measurement values can be checked one against the other.

The filter 6 produces a filter signal I from the received measurement values. This filter signal I can be, for example, the mean value of all received measurement values. It is, however, feasible for the filter signal I to be formed from the measurement values in other modes and manners.

The comparison signal FLAG and the filter signal I act on the evaluator 7. This produces a single output signal OUT from the two mentioned signals, which is led out of the housing 2 on a single output line 8. The output signal OUT corresponds with the filter signal I when the comparison signal FLAG = TRUE. If, thereagainst, the comparison signal FLAG = FALSE, the evaluator 7 does not pass on the filter signal I, but produces an output signal OUT which characterises a fault.

The output signal OUT can be an electrical signal K with a voltage value which lies outside a range that can be assumed by the filter signal I. If the filter signal I can vary, for example, between a maximum value +IMAX and a minimum value -IMAX, then the signal K can be, for example, greater than the value + IMAX.

The relationship between the comparison signal FLAG, the output signal OUT, the filter signal I, the maximum values + IMAX and -IMAX and the signal K characterising a fault is illustrated in the two lower time diagrams of Fig. 3.

Alternatively, it is possible for the evaluator 7 to produce a modulated output signal OUT, wherein the signal K is made recognisable by a different kind of modulation. Equally, it is possible that the filter signal is an analog signal, whilst the evaluator 7 produces the signal K as, for example, a signal keyed at a preset frequency.

The measuring equipment 1 thus produces on the output line 8 an output signal OUT which, when the measurement values representing the physical magnitude G do not deviate substantially from each other, produces the filter signal I corresponding with this magnitude G or, when the measurement values do deviate substantially from each other, produces the signal K characterising a fault. The microcomputer acted on by the output signal OUT can thus either, when the filter signal I is present on the output line 8, process this signal I further within the scope of, for example, a control and/or a regulation procedure or, when the output signal K is present on the output line, start an associated fault routine which, for example, reports the recognised fault to the driver of the vehicle. The measuring equipment 1 is thus in a position itself to recognise a fault that has occurred. In addition, the equipment 1 is able to indicate the recognised fault on one and the same output line 8. By virtue of these properties, the measuring equipment 1 has the status of a fail-silent device.

An electrical circuit, by which the equipment 1 of Fig. 1 can be realised, is shown in Fig. 2. Components in agreement with those in Fig. 1 are identified by corresponding reference symbols in Fig. 2 and are not described again.

Only the two sensors 3 and 4 are shown in the electrical circuit of Fig. 2. The measurement values produced by these sensors 3 and 4 are denoted by I_1 and I_2.

The measurement values produced by the sensors 3 and 4 are fed to the comparator 5, where they are applied by way of resistors 9 and 10 to an operational amplifier 11. With the aid of a resistor 12 connected as feedback and a resistor 13 connected to ground, the operational amplifier 11 is formed as differential amplifier. The amplifier 11 produces an output signal A, which is proportional to the difference of the measurement values produced by the sensors 3 and 4.

The output signal A of the operational amplifier 11 acts on a further operational amplifier 14, which is connected as pure amplifier. For this purpose, the amplifier 14 has a resistor

15 in a feedback as well as a resistor 16 connected to ground. The amplification factor of the operational amplifier 14 is set with the aid of the resistors 15 and 16 in such a manner that the output signal B of the amplifier 14 always assumes a maximum value when the output signal A acting on the operational amplifier 14 exceeds a preset limit value U_{Grenz} (Fig. 3).

The output signals A and B are entered as a function of time t in Fig. 3. The output signal A, thus the difference between the measurement values I_1 and I_2 of the sensors 3 and 4, initially fluctuates about a relatively small value. At the instant T_1, after which at least one of the sensors has a fault, the difference between the measurement values and thereby the output signal A rises strongly. The output signal A exceeds the preset limit value U_{Grenz}. Thereafter, the output signal A fluctuates about a value which is greater than the limit value. At the instant T_2, after which the two sensors are again fully capable of function, the output signal A again falls to a low value below the limit value.

This course of the output signal A has the consequence that the output signal B is initially about zero. This results from the output signal A being smaller than the limit value U_{Grenz} and the fact that operational amplifier 14 for that reason does not produce its maximum output signal B. After the instant T_1, in which the output signal A exceeds the limit value U_{Grenz}, the operational amplifier 14 produces its maximum output signal B. This output signal B is greater than a preset switching value U_{Schalt}. After the instant T_2, when the output signal A is again smaller than the preset limit value U_{Grenz}, the output signal B again falls back to about zero.

According to Fig. 2, the output signal B acts on the bases of two transistors 17 and 18. These transistors are coupled to resistors and connected to a positive operating voltage $+U_B$ and a negative operating voltage $-U_B$ as well as to ground. The output signals of the two transistors 17 and 18 are led together by way of respective diodes 19 and 20 and from there form the comparison signal FLAG.

It is also possible that the difference of the measurement values I_1 and I_2 produced by the sensors 3 and 4 and thereby the output signal A of the amplifier 11 assume negative values. In particular, it is possible that the output signal A assumes a large negative value which falls below a preset negative limit value $-U_{Grenz}$. This then has the consequence that

the output signal B of the operational amplifier 14 assumes a negative maximum value which is less than a preset negative switching value $-U_{Schalt}$.

The possibility that the output signal B of the amplifier 14 can assume positive and negative maximum values, is taken into consideration by the transistors 17 and 18 and the diodes 19 and 20. The transistor 17 and the diode 19 are connected in parallel with the transistor 18 and the diode 20, whereby an OR-interlinking of the output signals thus led together is obtained. This means that the comparison signal FLAG represents a binary signal, as is illustrated in Fig. 3.

If the output signal B is smaller in magnitude than the preset positive or negative switching value $+U_{Schalt}$ or $-U_{Schalt}$, the output signal FLAG assumes the binary value TRUE or "1". If, thereagainst, the output signal B is greater in magnitude than the preset positive or negative switching value $+U_{Schalt}$ or $-U_{Schalt}$, the output signal FLAG assumes the binary value FALSE or "0".

The filter 6 is not shown in detail in Fig. 2. As has already been explained, it can be of any kind by which a filter signal I, which best corresponds with both the measurement values I_1 and I_2, can be produced from the measurement values. This filter signal I as well as the comparison signal FLAG then act on the evaluator 7.

In particular, the comparison signal FLAG is fed to the base of a transistor 21, which is connected by way of resistors to the positive operating voltage $+U_B$ as well as to ground, and which is connected as a switch. The output signal of the transistor 21 is fed by way of a resistor 22 to an operational amplifier 23 connected as an inverting amplifier. The amplifier 23 is furthermore acted on by the filter signal I by way of a resistor 24. With the aid of a resistor 25, the operational amplifier 23 is connected as an inverting adder. This means that the output signal of the operational amplifier 23 corresponds with the sum of the filter signal I and the output signal of the transistor 21. This sum is then passed on to an operational amplifier 26, which with the aid of resistors is connected as inverting amplifier. The output signal of the operational 26 is available on the output line 8 of the evaluator 7 and represents the output signal OUT.

If the comparison signal FLAG has the positive value TRUE before the instant T1, this has the consequence that the transistor 21 blocks. In that case, no current flows by way of the

resistor 22 so that no contribution is supplied by way of the resistor 22 to the amplifier 23. In this case, the amplifier 23 amplifies only the filter signal I supplied by way of the resistor 24. This has the consequence that the output signal OUT before the instant T1 corresponds with the filter signal I.

In the time interval between the instants T_1 and T_2, the comparison signal FLAG is at the binary value FALSE and thus about zero. This has the consequence that the transistor 21 is conductive. Thereby, a current flows by way of the resistor 22 to ground. The resistors associated with the transistor 21 as well as the resistor 22 are selected in such a manner that this current flowing by way of the resistor 22 is greater than the maximum value +IMAX. The current flowing by way of the resistor 22 is added to the current corresponding with the filter signal 1 and flowing by way of the resistor 24. This has the consequence that the amplifier 23 produces its maximum output signal. In this manner, it is achieved that the output signal OUT corresponds with the signal K. As has already been explained, this signal K characterises a fault. The signal K is in that case greater than the maximum value +IMAX.

The maximum value +IMAX is a preset value which can be assumed by the comparison signal I at most. This means that the signal K is always distinguishable from the value +IMAX. In this manner, a microcomputer acted on by the output signal OUT can always recognise whether the output signal OUT corresponds with the filter signal I or the signal K characterising a fault.

CLAIMS

1. Electrical measuring equipment for producing an electrical signal corresponding with an actual magnitude, comprising a plurality of sensors for measuring the actual magnitude and producing measurement values indicative thereof and an electrical circuit for producing the electrical signal corresponding with the actual magnitude when the measurement values do not substantially differ from each other and for producing an electrical signal denoting a fault when the measurement values substantially differ one each other.

2. Equipment as claimed in claim 1, wherein the equipment has only one output line, by which either the signal corresponding with the actual magnitude or the signal denoting the fault is delivered.

3. Equipment as claimed in claim 1 or claim 2, wherein the signal denoting the fault lies outside a predetermined range of values of the signal corresponding with the actual magnitude.

4. Equipment as claimed in any one of the preceding claims, wherein the sensors are operable to measure the actual magnitude in different ways.

5. Equipment as claimed in any one of the preceding claims, wherein the circuit comprises a comparator arranged to produce a comparison signal dependent on the mutual deviation of the measurement values.

6. Equipment as claimed in claim 5, wherein the comparison signal is in binary form.

7. Equipment as claimed in any one of the preceding claims, wherein the circuit comprises means for producing a filter signal dependent on the measurement values.

8. Equipment as claimed in claim 6 when appended to claim 7, wherein the circuit comprises an evaluator which in dependence on the binary comparison signal passes on either the filter signal or the signal denoting the fault.

9. Equipment as claimed in any one of the preceding claims, wherein the actual magnitude is an operating parameter magnitude of a motor vehicle.

10. Measuring equipment substantially as hereinbefore described with reference to the accompanying drawings.

11. A method of producing an electrical signal corresponding with an actual magnitude, comprising the steps of producing a plurality of measurement values each indicative of the actual magnitude and producing either the electrical signal corresponding with the actual magnitude when the measurement values do not substantially differ from each other or an electrical signal denoting an error when the measurement values substantially differ from each other.

12. A method as claimed in claim 11, wherein the actual magnitude is an operating parameter magnitude of a motor vehicle.

13. A method as claimed in claim 11 and substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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Application No:	GB 9810877.2	**Examiner:**	J Betts
Claims searched:	1-13	**Date of search:**	3 November 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G1U (UR19165,UR1900,UR1910,UR3128 G3N (NGK1) G1N (NAHK)

Int Cl (Ed.6): G01R 19/165 19/00 19/10 31/28 G06F 11/16 11/18 G05B 23/02 H03K 19/003 19/23

Other: On-line: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2242037 A	(Bosch) whole doc. But see esp. Figs. 1-2	1,5,9,11,12
X	GB2229276 A	(Fuji Jukogyo) see esp. fig. 4	1,4,9,11,12
X	GB2075222 A	(General Signal) see Fig. 1B	1,5,6,9,11,12
X	GB1559394	(Consol. Coal) see fig.1	1,5,6,11
X	US5097712	(Endress) whole document	1,5,6,11
X	Patent Abstracts of Japan (JAPIO) JP57-125822 (Toshiba) see abstract and accompanying figure.		1,5,6,11

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.